WSTIAC

Volume I, Number 4
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WEAPON SYSTEMS TECHNOLOGY INFORMATION ANALYSIS CENTER

Joint DoD/DoE Munitions Technology Development

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Contents

WSTIAC is a DoD Information Analysis Center Sponsored by the Defense Technical Information Center and Operated by IIT Research Institute

Program Overview

In 1985 a memorandum of understanding between the Departments of Defense and Energy was signed for the purpose of cooperative research and development intended to bring about major improvements in non-nuclear munitions technology by adapting and leveraging the extensive nuclear weapons technology base at the national laboratories (Los Alamos, Livermore, and Sandia). In an atmosphere of joint research and mutually leveraged capabilities, this program supports the development and exploration of new munitions concepts and technology preceding system engineering development. The current program supports 37 projects in warhead technology, energetic materials, advanced initiation and fuze development, munitions lifecycle technology, and computer simulation. A specific Service laboratory sponsors each of these active projects. The program is administered and reviewed by a Joint Technical Advisory Committee composed of members from the Army, Navy, Air Force, OSD, and DOE. Projects are peer-reviewed semi-annually by DoD Service Laboratory/Technical Center personnel in order to monitor technical excellence and ensure that the technologies under development address priority DoD needs. A sampling of some of the mutually beneficial technologies which have been developed throughout the years, as well as ongoing research, is presented below.

Computational Mechanics and Simulation

A fundamental goal of the joint DoD/DOE munitions program is the leveraging of resources within both organizations towards problems of mutual interest. One such resource is an initiative within the DOE aimed at significantly advancing computational capability in the absence of nuclear weapons testing , the Accelerated Strategic Computing Initiative (ASCI). The joint program serves as a gateway through which researchers can transition

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applicable computational advances achieved at the national laboratories to DoD applications. An example of this sort of transition is ***CTH***: a family of codes, developed at Sandia National Laboratories (SNL), for modeling complex multi-dimensional, multimaterial problems that are characterized by large deformations and/or strong shocks. CTH was

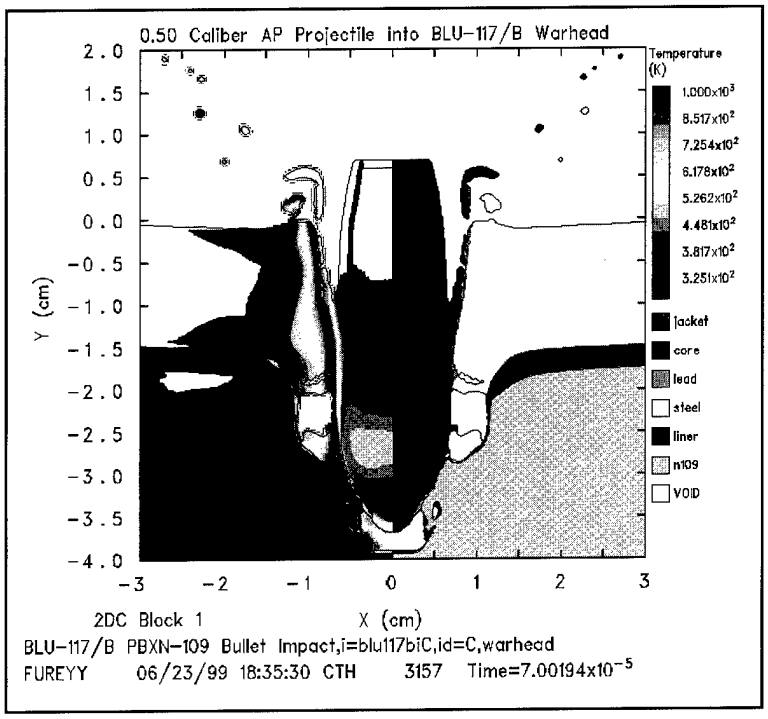

Figure 1. The CTH shock wave physics code has become a standard tool for DoD scientists and engineers. At 50 μs simulation time a plug of high temperature warhead casing is sheared out and pushed ahead of the 0.50 caliber bullet. The maximum transient temperature of the explosive is 600°K.

developed by SNL, improved and adapted to DoD problems, and then transitioned to the DoD community for use in warhead design and evaluation. It has become a heavily relied upon tool for warhead designers throughout the DoD. Figure 1 shows results from simulations performed by researchers at NAWC China Lake who used CTH to evaluate the response of the BLU-117A/B when subjected to bullet and fragment impact.

Numerical computation of the dynamic response of solids to explosive or impact loading requires mathematical descriptions of material behavior. These mathematical descriptions, commonly referred to as **material models**, are being developed in order to accurately predict how materials of interest to the DoD and DOE behave in a variety loading of regimes. Material models represent the harvest borne from significant intellectual investment in the experimental and theoretical understanding of how materials behave in dynamic environments. This effort involves development of the advanced mathematical models, implementation into existing 3D analysis codes (such as CTH, Pronto, EPIC, or ALE3D), and validation for use on an integrated DoD or DOE problem. As shown in Figure 2, this process is founded upon fundamental theory at small scales, guided by experimental input, and then validated for use on integrated large scale problems.

Areas currently being investigated include viscoelastic materials, damage and failure of ductile materials, anisotropic plasticity, brittle material behavior, shape memory materials, and heterogeneous metallic materials. The thrust of this work is on the synthesis of models and ideas from the fields of solid state physics and materials science rather than creation of a mathematical fit to a limited set of dynamic materials data.

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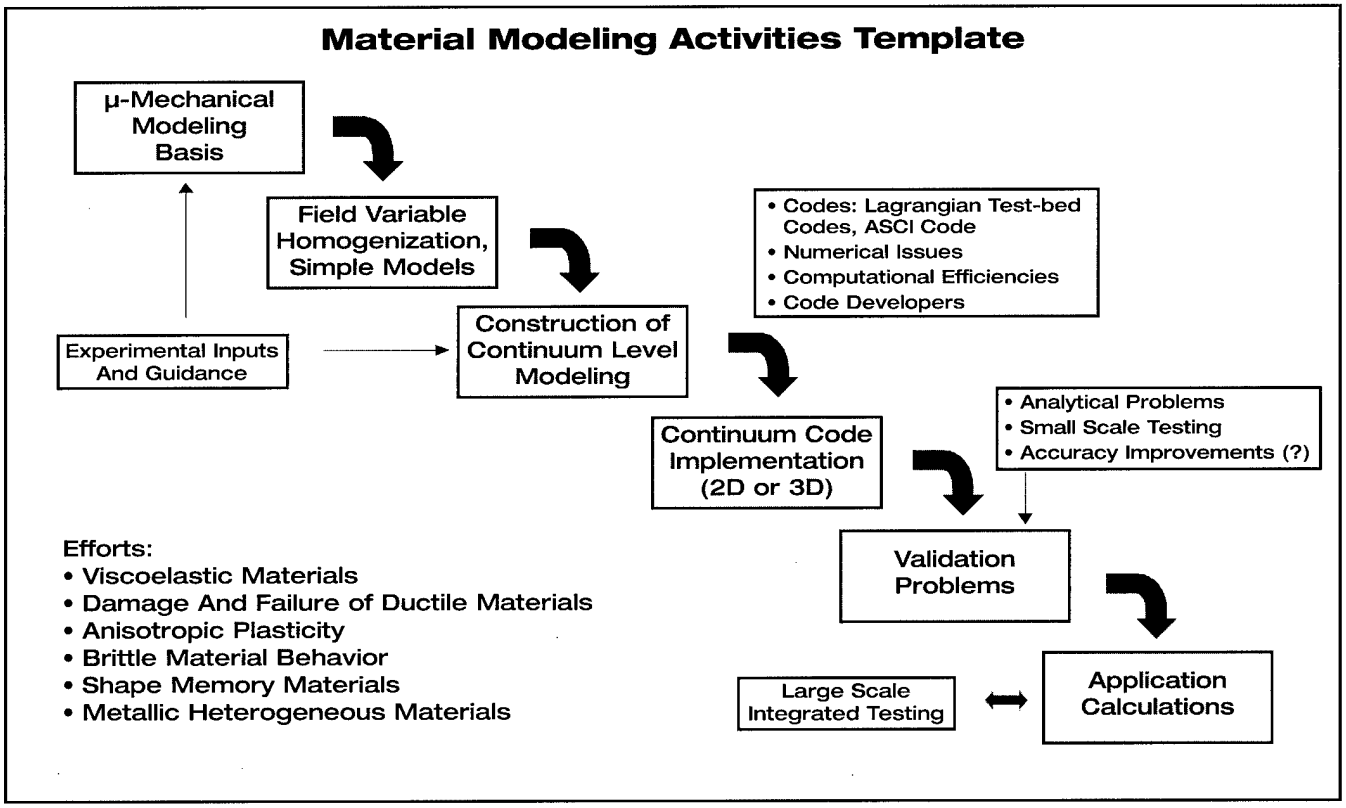

Figure 2. Template for material modeling activities.

Figure 3 shows the results of a "Taylor anvil" simulation, a commonly used, rigorous benchmark for material models in which a cylinder of material impacts a rigid wall and deforms. Depending upon the degree of anisotropy in the material, the cylinder's deformed "footprint" varies. Key to predicting the behavior of many DoD materials, an anisotropic model was developed and implemented into the EPIC analysis code to correctly represent this non-ideal behavior.

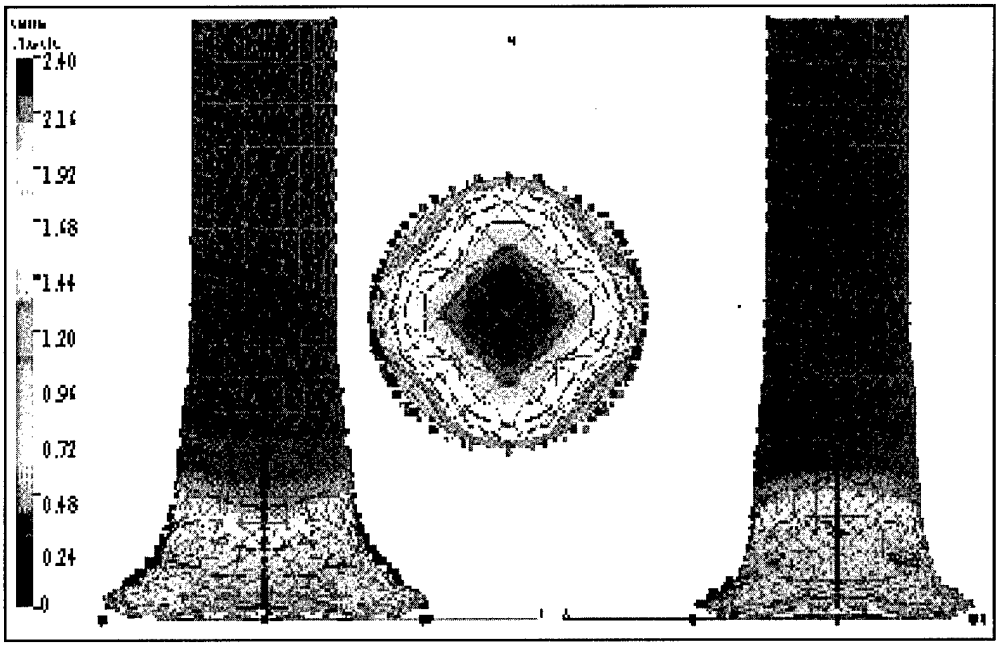

Figure 3. Comparison of Taylor cylinder impact simulation results showing major and minor side profiles and the impact-interface footprint at late-times with digitized experimental post-test shapes from three shots. Also shown are calculated contours of plastic strain ranging from 0 to 2.4.

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Innovative Warhead Technology

The fields of materials science, experiment and diagnostic design, applied physics, and, increasingly, computational mechanics, converge at conventional warhead design. Towards enhancing shaped charge jet penetration performance by mitigating participation, joint research has resulted in warhead ***material processing technology*** for production of very ductile metals which do not particulate as readily as standard materials. Figure 4 shows radiographs illustrating progressive improvements achieved by careful control of the thermo-mechanical and liner material selection processes.

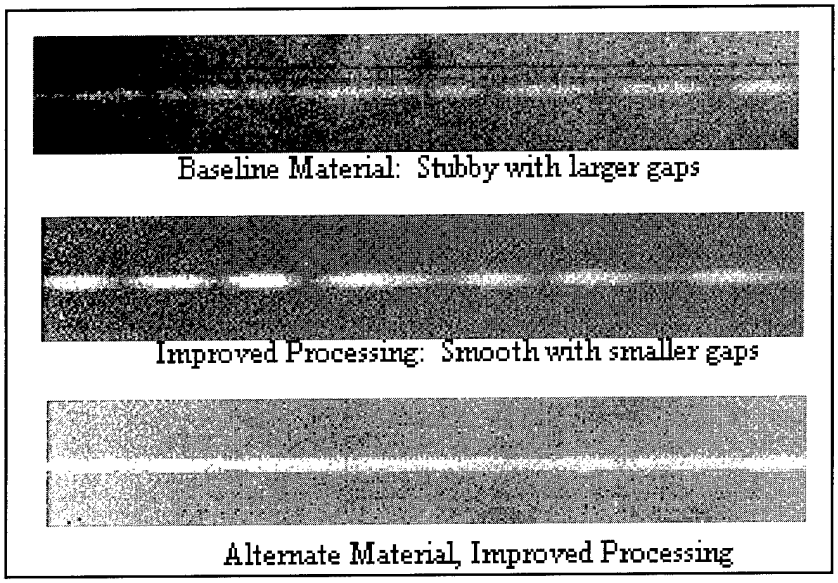

Figure 4. Radiographic images, taken at the same instant of time, showing the enhancement in performance which accompanies improved material processing and selection methods.

Given the heavy reliance on simulation and computing throughout the DoD and DOE, the ***GLO (Global Local Optimizer)*** code was created to exploit the utility of coupling nonlinear optimization methods with numerical modeling software. This software package serves as a versatile general purpose nonlinear optimization tool for investigating multi-parameter problems in science and engineering and has been successfully applied to the design of a shaped charge warhead to optimize its penetration into specific targets. GLO was first used to calibrate material property parameters for the jet and target by matching the tapered hole profiles from tests at various standoff distances. GLO was then used to redesign the warhead to create the desired hole profile in the target. The new warhead design was verified experimentally. Figure 5 shows the nominal parameters which were used for optimizing the warhead geometry.

Advanced Initiation and Fuze Development

Advanced initiation is an enabling technology for the next generation of warheads. It supports development of aimable warheads, target-adaptable warheads, and survivable high velocity hard target penetrators. This project is pointed toward improving the single point and multipoint slapper detonator initiation system technology, including miniature firing circuit and control capabilities, and applying it to DoD mission areas.

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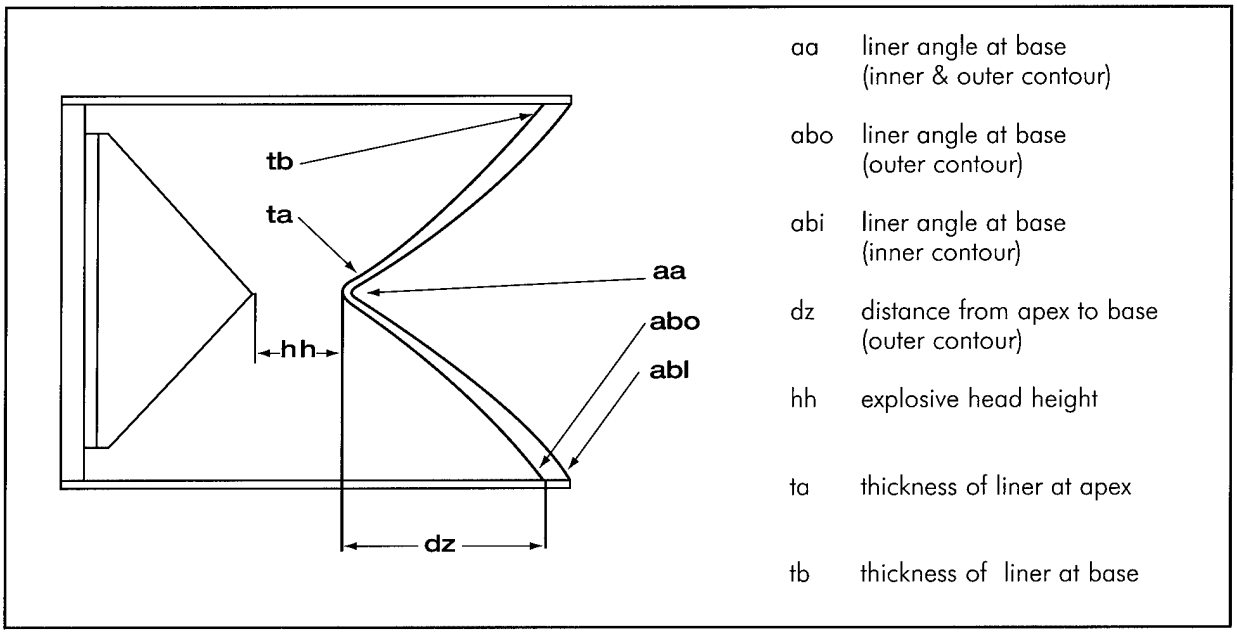

Figure 5. Parameters used for the GLO optimization of a generic warhead geometry.

Figure 6 shows miniature firing circuit components, developed through joint DoD/DOE research, which occupy less than 0.5 in^3 and were built with commercial components for less than $100. By leveraging the large DOE investment in micro-electromechanical systems (MEMS) and other areas, it is anticipated that further gains will be made in this area resulting in substantial cost and performance benefits to current and future DoD munitions which use in-line initiation systems.

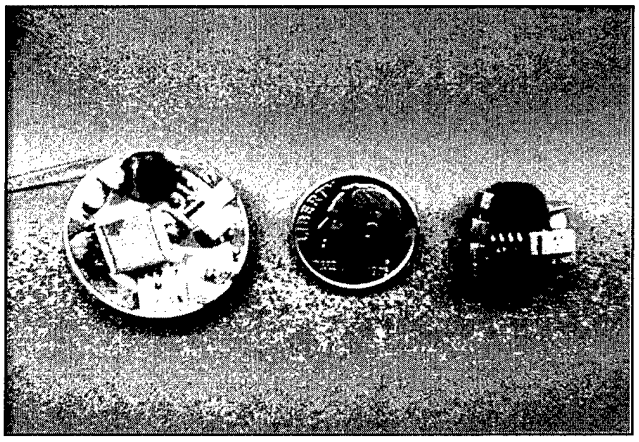

Figure 6. 1-kV Firing circuits less than 0.5 in^3 in volume built with commercial components for less than $100 and demonstrated to fire single slapper detonators.

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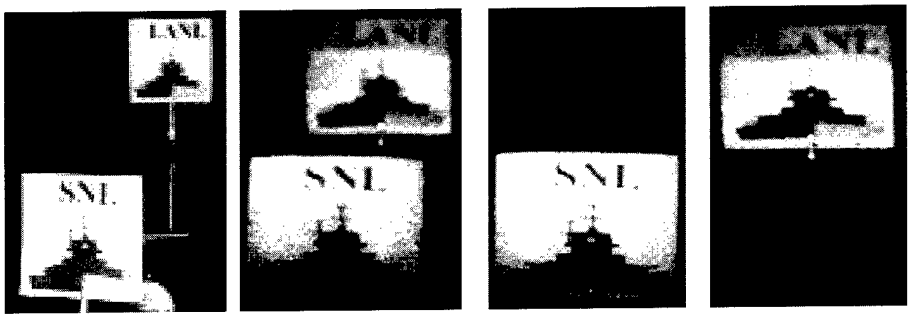
Advanced Image Sensor Technology

In the selective strike weapons system concepts of today, a critical and currently limiting component is the target detection and tracking sensor. This sensor is required to detect signals from distant targets, discriminate target return from spurious reflections and scatter, accurately determine range, and transfer data at a high rate to the data analysis and target identification elements of the system. Currently available sensors do not have the sensitivity, spectral response, dynamic range, and speed to fully meet the requirements of advanced weapon systems under development in the DoD. In response to these identified needs, ***the fast charge-coupled device*** (CCD) camera, capable of 4,000 frames/sec with 512 x 512 pixel array, has been developed by leveraging unique DOE capabilities in this area and adapting the technology to DoD needs. This camera system offers increased sensitivity, improved resolution, a high frame rate, and operation in the visible to near IR range and represents a unique technology and experience base that would otherwise not have been available for DoD applications. Current efforts are focused on integrating this technology into the Navy's Airborne Laser Mine Detection System (ALMDS) for a demonstration in FY01. Other potential DoD applications for this technology include Special Operations Forces (SOF) underwater imaging, optical fuzing for air to air munitions, and imaging of hypervelocity projectiles for active defense of armored vehicles.

Figure 7. Fast CCD Camera and laboratory scale imaging test results.



Munitions Lifecycle Technology

To safely dispose of munitions containing high explosives and other hazardous materials, it is necessary to gain access to the interior of the munition so that the contents may be removed. Because conventional machining techniques involve significant risk of an explosive reaction, a safer method is needed to cut open munitions casings and components that are likely to be in contact or close proximity to HE or other energetic materials. Current research is focused on using a ***femtosecond laser,*** which pulses for 100-150 fs at a rate of about 1 Khz, to cut energetic material with virtually no heat transfer and therefore, significantly reduced risk to personnel. The potential for cutting explosives, both bare and encased in steel, has been demonstrated using a femtosecond laser. Unlike conventional cutting lasers that melt and vaporize material, the femtosecond laser ablates material and produces no measurable heating. It offers unique capabilities for use in munitions demilitarization and manufacture. A dedicated femtosecond laser has been built in conjunction with a large blast chamber to allow the exploration of performing demil operations on full scale munitions. A demonstration this year used the laser to cut two metal tabs holding the fuse in the MLRS grenade. The precision cuts allow fuse removal and re-use of the grenade. Figure 8 shows an MLRS grenade before and after de-fuzing and Figure 9 shows the femtosecond laser which was constructed for the demil activities.

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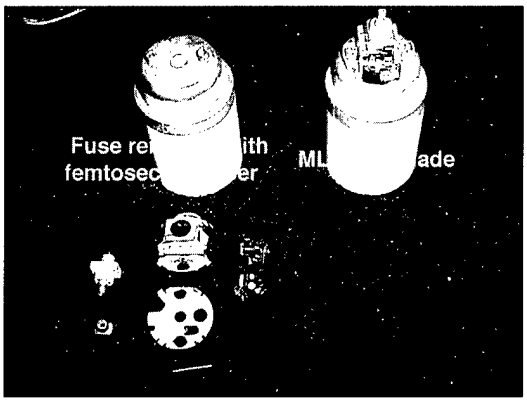
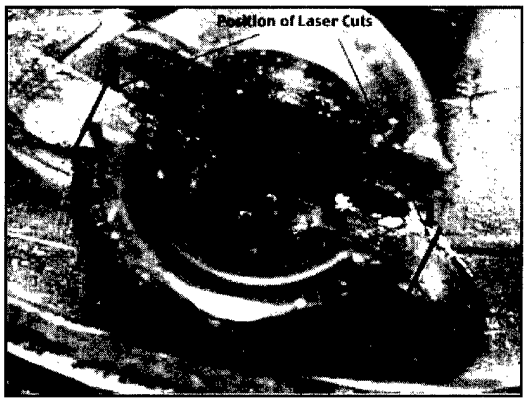


Figure 8. The MLRS grenade (a) before and after de-fuzing (b) close up view of tabs and laser cuts.



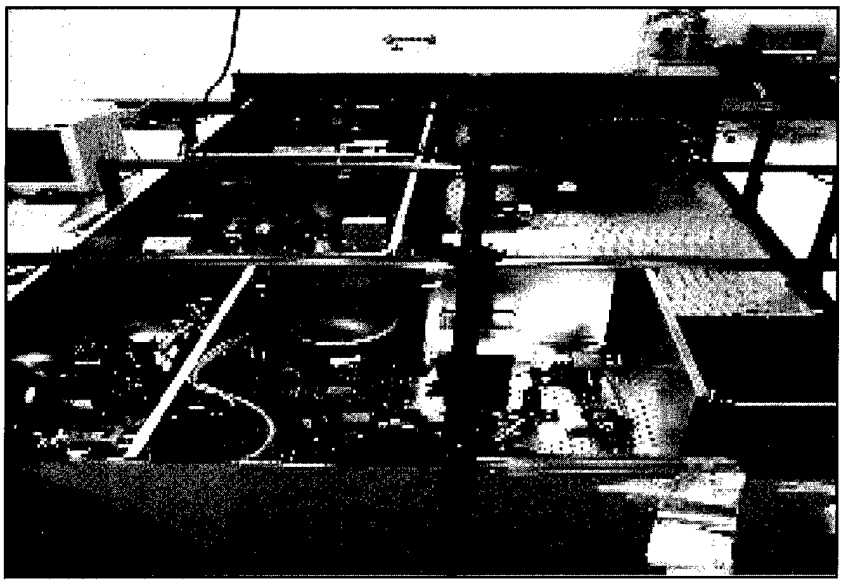


Figure 9. The femtosecond laser with the protective covers removed for viewing.

Summary

The joint DoD/DOE munitions technology research and development program is a cooperative, jointly funded effort between the DoD and DOE to pursue new and innovative warhead, explosive, and fuze technologies in order to bring about major improvements in non-nuclear munitions. A small sampling of some of the technology resulting from these collaborations has been presented. For a relatively small investment, this program effectively taps the annual billion-dollar DOE RDT&E investment by accessing the specialized skills, scientific equipment, facilities, and computational tools not available in the DoD. Please contact Mr. Steve Rojas, DoD Office of Munitions, if you would like further information about the Joint DoD/DOE munitions technology program. He can be reached at (703) 695-1407 or by e-mail at rojassp@acq.osd.mil.

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FYI...

GPS For Air and Space Power

For newsworthy items on the Global Positioning System, go to http://www.anser.org/publications/gps-news/. The "GPS For Air and Space Power" is an informal newsletter to the Air Force GPS community produced for SAF/AQPS and SAF/AQSS by ANSER Corp. GPS for Air and Space Power is based on published and submitted GPS news items. The most recent issue (dated 2 October 2000) contains articles on GPS precise positioning service (PPS), GPS modernization, Galileo, smart weapons' upgrades, and foreign low-cost cruise missiles. Archived copies go back to 1 January 1996.

DEPS

The Directed Energy Professional Society (DEPS) was founded in 1999 to foster research and development of Directed Energy technology for national defense and civil applications through professional communication and education. DEPS is currently planning for the 3rd Annual DE Symposium. It will be held during the week of 30 Oct 00 through 3 Nov 00. It will include short courses, tours, plenary sessions, and more in-depth technical sessions. In addition, this year's Symposium will have two public sessions (DE Vision 2000 and Basic Research). For more information go to http://www.deps.org/. The DOD Laser Master Plan published on 24 Mar 00 is also available at this site.

MEMS Clearinghouse

The MEMS Clearinghouse (http://mems.isi.edu/index.html) was established to be a repository of information about MicroElectroMechanical Systems (MEMS) and to foster communication and the rapid sharing of information within the MEMS community. It is run by the CHIME Project of the University of Southern California's Information Sciences Institute, under funding from the Defense Advanced Research Projects Agency's Electronics Technology Office (ETO), as part of the DARPA MEMS Program. Available at this site is an electronic discussion group; an events section announcing courses, conferences, calls for papers; a marketplace section for significant corporate events that impact the MEMS industry; yellow pages which contain information on companies that provide MEMS products and services, as well as information on people and other organizations associated with MEMS, such as research centers, universities, and local MEMS associations; a jobmart section, library and bookstore; the MEMS Material Properties Database and much more.

The WSTIAC Newsletter is the current awareness publication of the Weapon Systems Technology Information Analysis Center (WSTIAC). WSTIAC, a Department of Defense (DoD) Information Analysis Center (IAC), is administratively managed by the Defense Information Systems Agency (DISA), Defense Technical Information Center (DTIC) under the DoD IAC Program. The Contracting Officer's Technical Representative (COTR) for WSTIAC is Mr. H. Jack Taylor, ODUSD (S&T), Defense Pentagon, Washington, D.C. 20301-3080, (703) 588-7405. IIT Research Institute operates WSTIAC, which services Government, industry, and academia as a Center of Excellence in Weapon Systems Technology.

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Director/Chief Scientist's **Corner**

A View from Washington

by Dr. Wes Kitchens

I plan to use this "corner" of the WSTIAC Newsletter to comment on important developments in weapon systems technologies, programs and plans. The weapon systems technology work taking place today in our labs, development organizations, industry and academia will help shape joint warfighting for years to come as advanced weapons technologies are matured and weapon systems with improved capabilities are fielded. Joint Vision 2020 was published this summer by the Joint Chiefs of Staff to build upon and extend Joint Vision 2010 and help guide the continuing transformation of America's Armed Forces. Joint Vision 2020 describes the professional forces and operational capabilities required to succeed across the full range of military operations in 2020 and beyond. Today's capabilities for maneuver, strike, logistics and protection will transition over the next two decades into dominant maneuver, precision engagement, focused logistics and full dimensional protection, forming the foundation for achieving full spectrum dominance. Joint Vision 2020 does not list weapons, communications or other systems we need to develop and field in the future, nor does it describe the counters we need to employ to defeat specific threats. Rather, it focuses on how we can achieve full spectrum dominance through the interdependent application of dominant maneuver, precision engagement, focused logistics and full dimensional protection. The realization of full spectrum dominance will require a steady infusion of new technologies and modernized weapons, communications and other systems, as well as the development of doctrine, organizations, people and leaders that can effectively take advantage of these systems. The weapon systems technology community will play a critical role in helping shape Joint Vision 2020 and making it a reality.

Although the U. S. doesn't currently have any fielded laser weapons, laser technology offers great promise for future weapon systems and it may eventually provide our joint forces a significant technological edge over potential adversaries. High energy lasers can provide several benefits, including:

- deliver a lethal blow at the speed of light;
- deal effectively with high speed and highly maneuverable targets; and
- produce graduated terminal effects, ranging from less-than-lethal to lethal.

The DoD recently formed a High Energy Laser Joint Technology Office under the leadership of Mr. Alan R. Shaffer, Director for Multidisciplinary Systems, DUSD(S&T). This Joint Technology Office (JTO) will develop a DoD-wide high energy laser weapons investment and execution strategy and plan & manage a joint laser technology program. During FY01 the JTO will invest approximately $30M in critical underlying laser technology efforts. The members of the JTO staff are: Mr. Bill Barcley (DUSD(S&T)), LTC Mike Donovan (Army, SMDC), Mr. Joung Cook (Navy, NRL), Lt. Col. Terry Franks (Air Force, AFRL- DE), Mr. Steve Post (Air Force, AFRL-DE), MAJ Franz Gayl (Marine Corps), Maj. Kim McCrae (BMDO Focal Point) and Dr. Tim Grayson (DARPA Focal Point). Lt. Col. John Wisstler is expected to replace Lt. Col. Franks in January 2001. We wish Mr. Shaffer and the JTO staff great success in enhancing our high energy laser science and technology efforts and helping ensure that future laser weapons can realize their full potential.

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We have recently formed a WSTIAC Steering Committee to help ensure that WSTIAC is:

- closely coupled to the DoD weapon systems technology and warfighting communities;
- responsive to and supportive of DoD weapon systems technology scientific and technical information needs; and
- sustained as a valuable resource for providing weapon systems technology scientific and technical information to authorized users.

The Steering Committee will provide guidance on technical issues concerning the WSTIAC and its contributions to DoD weapon systems technology scientific and technical information. The Steering Committee will also review WSTIAC's overall performance and provide technical guidance for prioritizing WSTIAC's core program. The members of the Steering Committee are:

- Mr. H. Jack Taylor (Co-Chair) – DUSD(S&T) Weapons Systems Directorate, Rosslyn, VA;
- Mr. Ronald E. Hale (Co-Chair) – Defense Technical Information Center, Fort Belvoir, VA;
- Dr. Bruce W. Fowler, U.S. Army Aviation and Missile Command, Redstone Arsenal, AL;
- Dr. David L. Burdick, Naval Air Warfare Center Weapons Division, China Lake, CA;
- Mr. Frederick Davis, Air Force Research Laboratory, Eglin Air Force Base, FL;
- Mr. J. Thomas Hitchcock, OSD Office of Munitions, Pentagon, Washington, DC; and
- Mr. J. Frank Wattenbarger, U.S. Special Operations Command, MacDill Air Force Base, FL.

The Steering Committee held its first meeting in Alexandria, VA on 20 September 2000 where the members reviewed progress during WSTIAC's first year of operation and made a number of suggestions for expanding WSTIAC's value to warfighters and the RDT&E community.

This issue of our Newsletter highlights accomplishments and recent progress in the Joint DoD/DOE Munitions Technology Program. This Program, sponsored by the OSD Office of Munitions, was started in 1985 as the result of a Memorandum of Understanding signed between DoD and the DOE. Many critical conventional weapons-related technologies have been developed by the DOE Laboratories and transferred to the DoD through this program. The article discusses several examples of DOE-developed technologies that are making a difference in DoD weapons technology, development and/or production programs.◆

WSTIAC Wants Your Contributions

- We hope you find this issue of the WSTIAC Newsletter useful and interesting. You can help us to better serve you by your contributions, such as:
- Your comments on what you liked and disliked about the Newsletter
- Your suggestions for WSTIAC data products and services
- Technical articles, opinion pieces, tutorials, news releases or letters to the Editor for publication in the Newsletter
- To contact WSTIAC, use any of the ways listed on the back cover, or use the feedback form on the WSTIAC webpage
- We welcome your contributions.

Calendar of Events

Upcoming Conferences and Courses

6-7 November 2000
Technology Transfer and Import/Export Regulations in Foreign Military Sales
Washington D.C.
For additional information contact SMi Conferences
Tel: +44 20 7252 2222, Fax: +44 20 7252 2272
E-mail: customer_services@smiconferences.co.uk

7-9 November 2000
AIAA Missile Sciences Conference (SECRET/NOFORN)
San Diego CA
For additional information call 760.939.3409
Email: custserv@aiaa.org
http://www.aiaa.com/calendar/MSC00cfp.html

13-14 November 2000
Joint Battlefield Digitization
Washington D.C.
For additional information contact SMi Conferences
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E-mail: customer_services@smiconferences.co.uk
http://www.smiconferences.co.uk

14-17 November 2000
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Short Course/$1195
Georgia Institute of Technology
For additional information call 404.385.3502
Email: conted@gatech.edu
http://www.conted.gatech.edu

14-17 November 2000
Infrared/Visible Signature Suppression
Short Course/$1495
Georgia Institute of Technology
For additional information call 404.385.3502
Email: conted@gatech.edu
http://www.conted.gatech.edu

27-30 November 2000
Insensitive Munitions & Energetic Materials Symposium
San Antonio, TX
For additional information
Email: fbajowski@ndia.org
http://register.ndia.org/interview/register.ndia?~Brochure~155

12-14 February 2001
12th Annual SO/LIC Symposium & Exhibition
"Capabilities To Meet Future National Security Threats"
Crystal City, Arlington, VA
For additional information
Email: adekleine@ndia.org
http://register.ndia.org/interview/register.ndia?~Brochure~188

26-29 March 2001
US Army Gound Vehicle Survivability
Monterey, CA
For additional information
Email: fbajowski@ndia.org
http://register.ndia.org/interview/register.ndia?~Brochure~154

27-29 March 2001
Second Biennial National Forum on Weapon System Effectiveness
"The Weapon System as a Whole"
Applied Physics Laboratory
Laurel, MD
For additional information
http://www.aiaa.org/calendar/WSE01cfp.html

16-18 April 2001
45th Annual Fuze Conference
"The Evolving Nature of Value Added Fuzing"
Long Beach, CA
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Email: kdouglass@ndia.org
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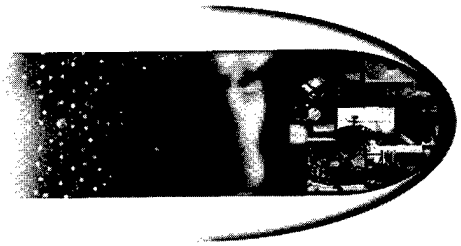

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